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**IMPERIAL MINERAL RESOURCES
BUREAU.**

**THE MINERAL INDUSTRY OF
THE BRITISH EMPIRE**

AND

FOREIGN COUNTRIES.

WAR PERIOD.

BORATES.

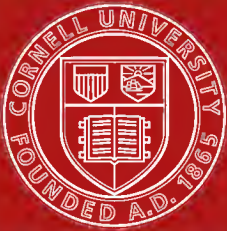
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PREFACE.

The following digest of statistical and technical information relative to the production and consumption of borates, will constitute a part of the Annual Volume on the Mineral Resources of the British Empire and Foreign Countries.

In this, the first year of publication, an effort has been made to fill in, as far as possible, the hiatus due to the war in the publications relating to mining and metallurgical statistics. Labour, health, and safety statistics have been omitted owing to the difficulty involved in procuring reliable information for the war period, but in future issues these statistics will be included in respect of each year.

Resort will also be had, to a much greater extent than at present, to graphical representation of statistics of production, consumption, costs and prices.

R. A. S. REDMAYNE,

Chairman of the Governors.

2, Queen Anne's Gate Buildings,

London, S.W. 1.

June, 1920.

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GENERAL.

The natural borates of commercial importance include (1) borax (hydrated sodium borate); (2) ulexite (hydrated borate of sodium and calcium); (3) colemanite (hydrated calcium borate); and (4) boracite* (borate and chloride of magnesium). Sassolite or native boric acid occurs chiefly in solution.

The following analyses show the composition of the more important commercial borates:—

	COLEMANITE. (California).	ULEXITE. (Chile & Peru).	"BORACITE." (Asia Minor).
Boric acid	40·19	44·38	45·89
Lime	31·89	16·14	30·62
Magnesia	1·50	·91	0·53
Iron and alumina	0·62	·48	0·98
Soda	—	6·50	—
Sodium chloride	—	7·46	—
Carbon dioxide	8·53	—	—
Sulphur trioxide	0·26	3·35	1·25
Water and organic matter	5·83	16·25	17·09
Insoluble matter	11·18	4·71	3·64
	100·00	100·18	100·00

Borax is a valuable flux for chemical and metallurgical purposes. It is used in the manufacture of pottery-glazes and enamels, and as a glaze for paper and linen. It is also used in tanning and glue manufacture. Its property of adhering closely to clean surfaces of metal under high temperature and preventing oxidation causes it to be largely employed in brazing and as a flux in brass manufacture. It is also used in the manufacture of soap and glass, and in numerous other ways. As an antiseptic it is used as medicine, and as a food preservative. Borate of chromium is used as a pigment in calico printing, and borates of manganese and lead as drying agents in the paint trade.

The perborates of sodium and calcium are used to generate pure hydrogen peroxide.

Boron and its compounds find a use in the copper industry. They act as scouring agents in molten copper, and copper castings of high electrical conductivity and dense quality are obtained by their use. Boron is also used in the manufacture of aluminium bronzes of great strength, in hardening and strengthening aluminium castings, and in the manufacture of nickel castings. Experiments conducted in France during the war showed that

* See footnote on p. 9.

by its use remarkably strong and tough steels were produced, but the results were not followed up as they should have been owing to the war, the pressure of work on all steel manufacturers, and on account of the difficulty in obtaining ferroboron.

Another use of boron is as a voltage regulator in incandescent lamps, arc lamps, and other devices on series circuits.

Borates are consumed almost wholly in the form of borax and boric acid, and of these two compounds borax is produced in larger quantities than boric acid.

Boric or boracic acid is usually prepared by treating ground borates with sulphuric acid. The borax of commerce is obtained chiefly from the mineral borates of lime by treating them with alkalies.

*World's Production of Borates.**

(In metric tons.†)

—	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Italy (crude boric acid) ...	2,410	2,537	2,497	2,293	2,335	2,210	
Argentine Republic (exports of calcium borate) ...	933	613	192	86			
Chile (calcium borate) ...	50,225	31,907	14,869	12,565			
Peru (borates) ...	2,001	1,263	510	1,289	800	523	
United States (crude borates)	52,678	56,624	60,801	93,943	98,798	80,575	

BRITISH EMPIRE.

No part of the British Empire produces borates at the present time, but large imports are recorded for the United Kingdom, Canada, Australia and South Africa.

United Kingdom.‡

Great Britain, prior to the war, imported the largest quantity of borax from France, but during the past few years it has been imported in increasing amounts from the United States. "Boracite" (Turkish pandermite) in pre-war times used to come

* Not including Turkey, the pre-war output of which exceeded 10,000 tons of borates annually.

† The metric, long and short ton referred to in this publication are equivalent to 2,204, 2,240 and 2,000 lb. respectively.

‡ Annual Statement of the Trade of the United Kingdom.

from Asiatic Turkey almost entirely, but the United States have made several large deliveries since 1914. The crude material is imported chiefly from Chile, Peru and Argentina.

Imports of Borate of Lime to the United Kingdom.

From	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United States	23,739	17,103	71,486	111,070	55,742	19,852	48,509
Argentine Republic ...	3,617	6,115	2,890	—	—	11,918	21,754
Chile ...	332,441	256,939	309,371	198,981	165,911	121,974	168,878
Peru ...	2,400	1,358	5,400	31,845	11,300	8,780	7,860
Other Foreign Countries	—	18	—	—	—	—	—
TOTAL ...	362,197	281,533	389,147	341,896	232,953	162,524	247,001

	Value (£).						
United States	10,908	8,030	37,124	76,374	62,160	37,704	52,170
Argentine Republic ...	1,385	2,390	1,236	—	—	14,259	21,775
Chile ...	134,934	106,920	140,432	128,716	185,890	149,701	184,441
Peru ...	960	624	2,430	21,393	13,278	10,317	9,075
Other Foreign Countries	—	5	—	—	—	—	—
TOTAL ...	148,187	117,969	181,222	226,483	261,328	211,981	267,461

*Exports of Borate of Lime from the United Kingdom
(Foreign Produce).*

Year.				Quantity cwts.	Value £
1913	...	...	...	—	—
1914	...	...	...	1,900	900
1915	...	...	...	9,405	4,257
1916	...	...	...	2,840	2,889
1917	...	...	...	414	500
1918	...	...	...	—	—
1919	...	...	...	2,000	2,350

Imports of Borax to the United Kingdom.

From	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
France	14,654	12,323	25,232	10,059	16,526	2,757	—
Germany	1,803	—	—	—	—	—	—
United States	3	—	—	8,017	20,963	13,728	33,972
Other Foreign Countries	480	1,179	—	50	—	—	—
TOTAL	16,940	13,502	25,232	18,126	37,489	16,485	34,012*

	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
France	12,934	11,238	27,680	14,802	27,243	5,094	—
Germany	1,609	—	—	—	—	—	—
United States	6	—	—	10,776	34,015	31,410	67,835
Other Foreign Countries	480	839	—	59	—	—	—
TOTAL	15,029	12,077	27,680	25,637	61,258	36,504	67,920*

*Exports of Borax from the United Kingdom
(Foreign Produce).*

To	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Russia	—	—	100	1,240	—	—	—
Japan	—	—	—	1,393	801	—	—
Other Foreign Countries	223	—	500	2,727	—	615	11,246
Total to Foreign Countries	223	—	600	5,360	801	615	11,246
Total to British Possessions	—	—	11	411	—	200	170
TOTAL	223	—	611	5,771	801	815	11,416

	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Russia	—	—	115	1,830	—	—	—
Japan	—	—	—	2,060	1,322	—	—
Other Foreign Countries	201	—	509	3,539	—	1,792	23,047
Total to Foreign Countries	201	—	624	7,429	1,322	1,792	23,047
Total to British Possessions	—	—	12	520	—	820	448
TOTAL	201	—	636	7,949	1,322	2,612	23,495

* Including 40 cwts. valued at £85 from British Possessions.

Imports of " Boracite "† to the United Kingdom.

From.	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Turkey, European ...	—	6,000	—	—	—	—	—
United States ...	—	2,991	—	11,000	—	—	25,213
Turkey, Asiatic ...	82,666	99,111	—	—	—	—	19,600
Other Foreign Countries ...	7,120	—	—	—	—	6,546	—
TOTAL ...	89,786	108,102	—	11,000	—	6,546	44,813

	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Turkey, European ...	—	3,000	—	—	—	—	—
United States ...	—	1,450	—	11,275	—	—	32,188
Turkey, Asiatic ...	36,453	43,068	—	—	—	—	19,600
Other Foreign Countries ...	3,290	—	—	—	—	6,800	—
	39,743	47,518	—	11,275	—	6,800	51,788

Exports of " Boracite " (Foreign Produce) from the United Kingdom.

To	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
France ...	—	10,800	9,368	—	—	—	—
Other Foreign Countries ...	—	1,600	—	—	—	—	—
TOTAL...	—	12,400	9,368	—	—	—	—

	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
France ...	—	4,860	4,028	—	—	—	—
Other Foreign Countries ...	—	710	—	—	—	—	—
TOTAL...	—	5,570	4,028	—	—	—	—

† " Boracite " is the name applied in the mineral trade to Turkish pander-mite, and appears to be used in this sense in the " Annual Statement of Trade of the United Kingdom."

Union of South Africa and Rhodesia.*

The imports of borax into the Union of South Africa have fluctuated very considerably during the past few years. By far the largest proportion is imported from the United Kingdom, though recently increased supplies have been obtained from the United States. The exports go chiefly to the South-West African Protectorate, the islands of Mauritius and St.*Helena, and to Portuguese East Africa.

Fairly large amounts of borax are exported to Southern Rhodesia from Great Britain. Exports from Southern Rhodesia are small and are confined to the Union of South Africa, Northern Rhodesia, the Belgian Congo and Portuguese East Africa.

Imports of Borax to the Union of South Africa.

From.	Quantity (lb.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom...	823,004	765,919	870,415	1,031,343	420,838	526,376	
Canada	—	—	—	—	224	—	
France	—	—	112	168	200	—	
Germany	2,846	13,784	112	—	—	220	
Holland	280	448	—	—	—	—	
Italy	1,232	—	—	20	560	—	
United States ...	448	448	112	2,784	4,912	133,118	
Argentine Republic	—	—	—	—	—	6,532	
Japan	—	—	—	—	—	2,800	
TOTAL ...	827,810	780,599	870,751	1,034,315	426,734	669,046	

	Value (£)					
	1913.	1914.	1915.	1916.	1917.	1918.
United Kingdom...	12,570	12,333	16,631	24,675	11,769	16,204
Canada	—	—	—	—	4	—
France	—	—	1	5	10	—
Germany	45	165	2	—	—	8
Holland	6	3	—	—	—	—
Italy	11	—	—	1	15	—
United States ...	3	3	1	91	113	4,173
Argentine Republic	—	—	—	—	—	219
Japan	—	—	—	—	—	152
TOTAL ...	12,635	12,504	16,635	24,772	11,911	20,756

* Annual Statement of the Trade and Shipping of the Union of South Africa and of Southern and Northern Rhodesia.

*Exports of Borax from the Union of South Africa
(Foreign Produce).*

To.	Quantity (lb.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Mauritius	—	—	—	—	—	1,200	
St. Helena	—	—	—	—	—	9	
South-West Africa							
Protectorate ...	—	—	56	453	1,037	694	
Belgian Congo ...	—	—	56	—	642	224	
Madagascar ...	—	—	—	—	2	—	
Portuguese East							
Africa	—	11,200	—	1,672	1,082	2,810	
Portuguese West							
Africa	—	—	—	—	—	336	
TOTAL	—	11,200	112	2,125	2,763	5,273	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Mauritius	—	—	—	—	—	20	
St. Helena	—	—	—	—	—	1	
South-West Africa							
Protectorate ...	—	—	1	19	41	30	
Belgian Congo ...	—	—	1	—	25	9	
Madagascar... ..	—	—	—	—	—	—	
Portuguese East							
Africa	—	239	—	26	34	119	
Portuguese West							
Africa	—	—	—	—	—	17	
TOTAL... ..	—	239	2	45	100	196	

Imports of Borax to Southern Rhodesia.

From	Quantity (lb.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	58,630	125,643	134,101	150,865	86,431	87,284	
Germany	—	224	—	—	—	—	
United States ...	—	5,000	5,000	—	—	—	
South African							
produce	—	—	—	—	—	14	
TOTAL	58,630	130,867	139,101	150,865	86,431	87,298	
	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	998	2,353	2,773	3,711	2,575	3,102	
Germany	—	1	—	—	—	—	
United States ...	—	116	108	—	—	—	
South African							
produce	—	—	—	—	—	1	
TOTAL	998	2,470	2,881	3,711	2,575	3,103	

*Exports of Borax (Foreign Produce) from
Southern Rhodesia.*

To.	Quantity (lbs.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Union of South Africa ...	—	224	112	448	112	—	
Northern Rhodesia ...	—	112	—	—	112	—	
Belgian Congo ...	—	—	15	9	121	177	
Portuguese East Africa ...	224	140	267	280	14	127	
TOTAL ...	224	476	394	737	359	304	

	Value (£).						
Union of South Africa ...	—	2	1	8	2	—	
Northern Rhodesia ...	—	1	—	—	2	—	
Belgian Congo ...	—	—	1	—	4	10	
Portuguese East Africa ...	6	5	8	12	1	9	
TOTAL ...	6	8	10	20	9	19	

Canada.*

Canada produces no borates. At the outset of the period under review she imported large quantities of boric acid and borax from the United Kingdom. As shown by the following tables, however, these imports from the United Kingdom fell seriously during the war and the imports from the United States increased largely.

*Imports of Boric Acid to Canada for Fiscal
Years ending March 31.*

From	Quantity (lb.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	381,544	261,105	107,663	62,246	22,764	42,682	
France ...	8,900	13,840	—	—	—	—	
Germany ...	700	78,928	6,720	—	—	—	
United States ...	22,306	38,147	272,355	298,253	390,644	343,444	
Total of Foreign Countries ...	31,906	130,915	279,075	298,253	390,644	343,444	
TOTAL ...	413,450	392,020	386,738	360,499	413,408	386,126	

* Annual Statement of the Trade and Commerce of Canada.

From	Value (\$).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	18,793	15,916	7,653	4,570	2,411	5,491	
France ...	716	1,198	—	—	—	—	
Germany ...	52	5,133	459	—	—	—	
United States ...	1,732	2,699	17,866	28,327	47,284	43,468	
Total of Foreign Countries ...	2,500	9,030	18,325	28,327	47,284	43,468	
TOTAL ...	21,293	24,946	25,978	32,897	49,695	48,959	

Imports of Borax, in Bulk of not less than 25 pounds, to Canada for Fiscal Years ending March 31.

From	Quantity (lb.).						
	1912-13.	1913-14.	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
United Kingdom ...	2,537,334	2,239,431	992,603	365,681	359,937	105,395	
Hong Kong ...	—	—	—	—	—	40	
Total of British Empire ...	2,537,334	2,239,431	992,603	365,681	359,937	105,435	
France ...	—	3,010	—	—	—	—	
Germany ...	6,983	3,920	2,240	—	—	—	
United States ...	540,800	412,235	2,041,498	2,712,359	3,774,281	4,164,749	
Total of Foreign Countries ...	547,783	419,165	2,043,738	2,712,359	3,774,281	4,164,749	
TOTAL ...	3,085,117	2,658,596	3,036,341	3,078,040	4,134,218	4,270,184	

	Value (\$).						
United Kingdom ...	94,991	85,930	38,165	19,746	28,029	10,483	
Hong Kong ...	—	—	—	—	—	3	
Total of British Empire ...	94,991	85,930	38,165	19,746	28,029	10,486	
France ...	—	148	—	—	—	—	
Germany ...	277	156	92	—	—	—	
United States ...	17,486	15,567	87,811	153,795	269,097	327,123	
Total of Foreign Countries ...	17,763	15,871	87,903	153,795	269,097	327,123	
TOTAL ...	112,754	101,801	126,068	173,541	297,126	337,609	

India and Tibet.*

The borax or tincal deposits occurring in Tibet were probably the first borates ever utilized. About 220 tons are exported annually from India, and this, which is practically all obtained from Tibet and Ladakh, is imported across the frontier into the Punjab and United Provinces. Herds of sheep and goats may be met in the Himalayan passes coming down from Tibet in the spring, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

Until the extensive discoveries of calcium borate in America about 25 years ago, there was a very much greater demand for the borax of Tibet, but now the only large customers are China and the Straits Settlements. The trans-frontier imports of borax in recent years have been about 25,000 cwt. annually. The internal consumption in India has increased to some extent, and the export trade has declined.

The material exported from Tibet is obtained from salt lakes which have possibly obtained their borax from volcanic sources. The borax obtained from the Puga Valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which are regarded as evidence of waning volcanic action.

Imports of Borax (including Boric Acid) by Sea to India for Fiscal Years ending March 31.

From.	Quantity (cwts.).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	6,598	4,825	5,800	8,250	7,225	9,087	
Hong Kong ...	—	—	—	—	—	70	
Other British Possessions ...	—	—	—	5	—	37	
Total of British Empire ...	6,598	4,825	5,800	8,255	7,225	9,194	
France ...	—	—	—	—	—	184	
Germany ...	90	429	499	20	—	—	
Other Foreign Countries ...	—	1	2	—	—	—	
Total of Foreign Countries ...	90	430	501	20	—	184	
TOTAL ...	6,688	5,255	6,301	8,275	7,225	9,378	

* Annual Statement of the Sea-borne Trade of British India.

From	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	6,048	5,112	6,405	11,852	13,647	20,307	
Hong Kong ...	—	—	—	—	—	209	
Other British Possessions ...	—	—	—	7	—	75	
Total of British Empire ...	6,048	5,112	6,405	11,859	13,647	20,591	
France ...	—	—	—	—	—	567	
Germany ...	95	445	500	21	—	—	
Other Foreign Countries ...	1	2	2	—	—	—	
Total of Foreign Countries ...	96	447	502	21	—	567	
TOTAL ...	6,144	5,559	6,907	11,880	13,647	21,158	

Exports of Borax by Sea from India, for Fiscal Years ending March 31.*

Year.	Quantity.		Value.
	Cwts.		£
1912-13	4,770	7,457
1913-14	4,270	5,131
1914-15	4,461	6,191
1915-16	6,252	10,010
1916-17	7,353	14,102
1917-18	2,873	5,875
1918-19	4,939	10,634

Australia.†

Australia imports its supplies of boric acid and borax chiefly from the United Kingdom.

* In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, Kelat, Afghanistan, Tibet, and China. During the six years, 1908-9 to 1913-4, these trans-frontier exports of borax have averaged 9 cwts. a year, with an average value of Rs. 18·8 (2s.) per cwt.

† Trade and Customs and Excise Revenue of the Commonwealth of Australia (Annual).

*Imports of Boric Acid to Australia for Fiscal Years ending
June 30.*

From.	Quantity (cwts.).				
	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
United Kingdom ...	6,746	5,349	5,980	6,350	
Canada	—	—	1	97	
New Zealand	—	—	—	51	
Other British Countries	4	27	—	—	
United States	14	1	10	609	
TOTAL	6,764	5,377	5,991	7,107	

	Value (£).				
	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
United Kingdom ...	10,825	10,879	17,540	22,505	
Canada	—	—	4	335	
New Zealand	—	—	—	182	
Other British Countries	8	51	—	—	
United States	27	1	36	2,404	
TOTAL	10,860	10,931	17,580	25,426	

FOREIGN COUNTRIES.

Germany.

Boracite occurs as crystals, concretions, and granular masses associated with potash minerals in salt deposits of Permian age at Stassfurt in Germany. Rock salt, which is found almost throughout the section, contains disseminated borates, but the carnallite zone, measuring 30 to 40 metres in thickness, yields most of the crude boracite.

There are no figures available as regards production or value since 1912.

Italy.*

Sassolite or crystallized boric acid is obtained in considerable quantities from gaseous emanations which come to the surface through innumerable fissures or dislocations in the Eocene and Cretaceous rocks of Central Italy. These fumarole deposits occur chiefly in the province of Pisa in the parishes of Pomarance, Castelnuovo di Val di Cecina, Massa Marittima, and Montieri.

There are a number of "blowers" (soffione) of steam and other gases in this vicinity, and where they occur a pit is dug around and water run in. The hot steam and gases make the water boil up, leaving a little boric acid in solution. The escaping gases are steam, carbon dioxide and nitrogen, with

* Rivista del Servizio Minerario (Annual.)

a little oxygen and sulphuretted hydrogen. The very weak boracic solution is concentrated by the heat which is derived from the soffione.

The output, as is shown in the following tables, has remained fairly constant throughout the period, but the value of the crude boracic acid has increased by about 365 per cent.

Production of Crude Boric Acid in Italy.

Year.	Quantity. Metric tons.			Value. £.*
1913	2,410		37,596
1914	2,537		41,607
1915	2,497		54,934
1916	2,293		89,886
1917	2,335		121,420
1918	2,210		114,920
1919			

Production of Refined Boric Acid and Borax in Italy.

Year.	Refined Boric Acid.		Borax.	
	Quantity. Metric Tons.	Value. £.*	Quantity. Metric Tons.	Value. £.*
1913... ..	743	16,353	1,071	17,561
1914... ..	839	19,453	1,164	20,493
1915... ..	1,277	43,411	829	23,201
1916... ..	1,114	—	554	—
1917... ..				
1918... ..				
1919... ..				

Imports of Crude and Refined Boric Acid and Borax to Italy.

Year.	Boric Acid, Crude and Refined.		Borax.	
	Quantity. Metric Tons.	Value. £.*	Quantity. Metric Tons.	Value. £.*
1913... ..	21	585	138	2,489
1914... ..	3	93	277	5,540
1915... ..	3	10	718	14,362
1916... ..	1	104	983	49,165
1917... ..	—	—	632	44,240
1918... ..	—	—	350	24,528
1919... ..				

* Value converted to £ sterling at the rate of 25 lire = £1.

Exports of Crude and Refined Boric Acid and Borax from Italy.

Year.	Crude Boric Acid.		Refined Boric Acid.		Borax.	
	Quantity. Metric tons.	Value. £.*	Quantity. Metric tons.	Value. £.*	Quantity. Metric tons.	Value. £.*
1913	772	16,047	571	15,988	30	542
1914	669	16,063	521	16,672	4	88
1915	367	8,818	1,185	37,923	149	2,986
1916	274	15,361	1,293	95,689	530	26,480
1917	108	10,387	1,000	110,066	4	294
1918	125	11,990	1,208	132,902	2	147
1919						

Turkey.

Borates have been known in Asia Minor since ancient times in the vilayet of Brusa at Sultan-Chair near Panderma, whence the local name "pandermite" is derived. Though harder, pandermite is closely allied to colemanite, which is a hydrated borate of calcium. It contains a higher percentage (56 per cent.) of boric acid than any other borate except boracite. The potters formerly established along the coast used borates for glazing large earthenware pots, which they decorated in striking colours and sent to Constantinople for sale. The modern exploitation began about the year 1899, when numerous old galleries were discovered, leading to the belief that the borate had been worked by the Genoese, but the Dardanelles potters used the borax years before the advent of the Genoese.

Sultan-Chair, which is the mining centre, lies between the Manissa-Sona-Panderma branch of the Smyrna-Cassaba railway, 37 miles south-west of Panderma and 51 miles south-west of Brusa. The basin of Sultan-Chair lies among hills of schist and granite of early geological age. Sedimentary deposits of later age, chiefly gypsum, have accumulated to a great depth. Volcanic upheaval during the period of the gypsum formation no doubt caused the trachyte outflow which is found to the north of the basin, at the same time giving rise to the fumaroles of boric acid.

Pandermite is hand-sorted and sifted before exportation.

Argentina.†

Deposits of borates are found in Los Andes and the immediately adjacent portions of Jujuy, Salta, and Catamarca in large salt lakes and salares. The borate usually occurs mixed with calcium and sodium sulphate, sodium and magnesium chloride, oxide of iron, and more or less sand and clay. It is found partly as layers

* Value converted to £ sterling at the rate of 25 lire = £1.

† Estadística Minera de la República (Annual).

of massive material and partly as pebbles and concretions, the latter form being the richer in boric acid. The deposits are much the same as those found in Chile and Peru, and have originated presumably from the deposit around the outlets of thermal waters being carried down into the salares by rains.

The Tres Morros, which is the most actively worked deposit in Argentina, consists of a layer of concretions 80 to 100 cm. thick, containing about 37 per cent. of boric anhydride. Most of the borate deposits are under the control of the International Borax Company, but as these deposits are not readily accessible, they are not being very actively developed at the present time.

About 650 tons is produced annually for export purposes, and about the same amount for home consumption.

Exports of Calcium Borate from the Argentine Republic.

Year.	Quantity.			Contents of
	Metric tons.			B ₂ O ₃ , Metric tons.
1913	933	330
1914	613	225
1915	192	79
1916	86	34
1917		
1918		
1919		

Chile, Peru and Bolivia.

Borates occur in the form of ulexite throughout the desert regions of Atacama. At Ascotan, on the borders of the Republic, and Maricunga, to the north of Copiapo, the operations are proving successful.

The deposits are extensive, and are found in desiccated lakes known as salares. These salares are extensively scattered over the arid portions of northern Chile, and, though probably all contain some borate, only a small proportion contain sufficient to render them workable. The richest salares are those of the valleys of the High Andes in the vicinity of the recent volcanoes, many of which still have active fumaroles.

The Salar de Ascotan is much the largest, and, connected as it is with the coast by the Antofagasta-La Paz railway, it is the centre of practically all the borate mining of Chile. It is about 24 miles in length and 6 miles wide at the broadest part. In the sunshine the salar presents a dazzling appearance, for, excepting a small pool of water here and there, the entire area is covered with glistening white crystals of various salts.

On the eastern side there are several volcanoes with well-preserved craters, some of which have active fumaroles. The salar is situated at an altitude of 12,220 feet above sea level, and the adjoining volcanic mountains range from 18,000 to 19,600 feet.

In parts the ulexite is found practically free from impurities, but elsewhere it is associated with sodium chloride, sodium sulphate, and calcium sulphate. The thickness of the rich strata is usually not more than a foot, but considerably thicker beds have been reported.

The origin of the borate deposits of Chile and south-western Bolivia is to be found in the recent volcanoes which are so prominent in that district. The aridity of the climate is such that there is no drainage system, and the very small rainfall finds its way very quickly into the valleys, where the water evaporates and leaves its dissolved salts as a residue.

Borates are found along the boundary between the departments of Arequipa and Moquega at Laguna de Salinas, about 12 miles east of Arequipa city. The lake is some eight miles in circumference and lies at an altitude of 18,000 to 20,000 feet. It is dry practically throughout the whole of the year, and the borates form an irregular layer, the upper crust consisting of chloride and sulphate of soda followed successively by fine sand, coarse sand, sand with borate layers, thin layers of sand₂ and a 40 c.m. to 1 m. layer of borates.

The mineral is ulexite or boronatrocalcite. It contains 30 per cent. of boric acid in the crude state and 52 per cent. after being calcined. In the dry plains of Iquique it is found in the form of rounded masses varying from the size of a hazel nut to that of a potato and associated with pickeringite, glauberite, rock salt, and gypsum.

The great difficulty experienced in the development of these deposits is in the matter of transportation, all the produce having to be transported over the great mountain range to the coast. This western range of the Andes of South America, known as the Cordillera Occidental, and extending through Peru, Bolivia, Chile and into the Argentine, contains many lofty volcanoes recently extinct, from some of which sulphurous gases are still escaping. About the base of these mountains borax lakes are sufficiently numerous to supply the world for many centuries to come, but as yet few of them have been worked.

Almost the whole of the deposits are at present owned and worked by a British Company, Borax Consolidated, and prior to the war this company was in negotiation with the Peruvian Government with a view to building a railway to facilitate the transport and the development of this area. It was estimated that the project would cost £300,000; but it was abandoned at the outbreak of war. It is anticipated that with the termination of war this scheme may be reconsidered, and it would doubtless open up many enterprises in this promising region of Peru.

Production of Calcium Borate in Chile.

Year.					Quantity. Metric Tons.
1913	...	...	...	...	50,225
1914	...	...	...	...	31,907
1915	...	...	...	...	14,869
1916	...	...	...	...	12,565
1917	...	...	...	...
1918	...	...	...	...
1919	...	...	...	...

Production of Borates in Peru.

Year.					Quantity. Metric Tons.
1913	...	...	...	...	2,001
1914	...	...	...	...	1,263
1915	...	...	...	...	510
1916	...	...	...	...	1,289
1917	...	...	...	...	800
1918	...	...	...	...	523
1919	...	...	...	...

United States.*

Throughout the Great Basin region of the western United States, and in particular in the counties of Inyo, Kern and San Bernardino in California, and that portion of south-west Nevada adjoining Inyo County, there are numbers of lakes or marshes the waters of which are rich enough in borates and other sodium salts to repay extraction. In many cases the lakes have dried up, and the bed consists of mud, alkali, salt and borates mixed with sandy matter. The borates of these marsh deposits are all secondary, and the borax contents are derived from beds of colemanite in the Tertiary lake sediments of the surrounding hills.

These beds extend to the Pacific coast at Piru, Ventura County and near Saugus, Los Angeles County, where they form part of a series of yellow clays and sandstones, probably of Miocene age. The borates are present as nodules in the clay, and are covered by a stratum of gypsum.

The borates are calcined at the mines and treated for the purpose of eliminating impurities such as pandermite, clay and water. The colemanite becomes dehydrated by calcination and yields

* Mineral Resources of the United States (Annual).

a fine powder which is easily screened from the pandermite and clay. Borax is obtained from colemanite by treatment with sodium carbonate.

Large undeveloped deposits of colemanite are known to exist, and, though the demand for borax and boric acid is considerable, there appears to be no doubt that the deposits are practically inexhaustible.

A new factor in the borax industry is provided by the saline deposits of the western desert region, which have recently come into prominence as possible sources of potash, carbonate of soda, common salt and other products, including borax. It seems not improbable that borates will eventually be obtained as by-products from these deposits.

Production of Crude Borate in the United States.

Year.	Quantity. Short tons.	Value. \$
1913	58,051	1,491,530
1914	62,400	1,464,400
1915	67,003	1,677,099
1916	103,525	2,409,459
1917	108,875	3,609,632
1918	88,794	2,179,830
1919		

Imports of Borax and Borates for Consumption in the United States.

Year.	Borax.		Borates, calcium and sodium (crude) and refined sodium borate.		Boric acid.	
	Quantity. lb.	Value. \$	Quantity. lb.	Value. \$	Quantity. lb.	Value. \$
1913 ...	4,215	477	7,900	1,025	423,215	16,932
1914 ...	220	29	3,862	546	425,241	18,837
1915 ...	—	—	2,748	393	442,073	20,888
1916 ...	83	3	703	135	354,710	19,905
1917* ...	—	—	614	109	404,210	24,590
1918 ...	2	1	10,000	50	259,096	26,436
1919 ...						

* Fiscal year ending June 30.

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